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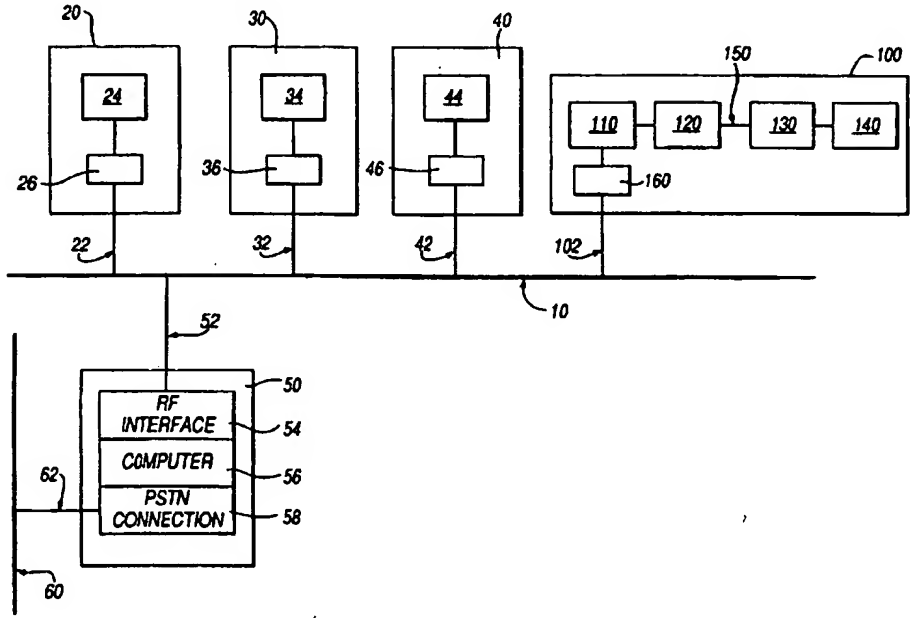
(71) Applicant(s)
Roke Manor Research Limited
(Incorporated in the United Kingdom)
Roke Manor Research, Old Salisbury Lane, ROMSEY, Hampshire, SO51 0ZN, United Kingdom

(72) Inventor(s)
Gordon William Chambers

(74) Agent and/or Address for Service
Margaret D Mackett
Siemens Group Services Limited, Intellectual Property Department, Siemens House, Oldbury, BRACKNELL, Berks, RG12 8FZ, United Kingdom

(54) Abstract Title
Data transmission

(57) Described herein is a means by which Internet access can be obtained via normal power lines. An electricity substation (50) includes at least one RF interface (54), a computer (56) and a PSTN connection (58) for connecting it to a telephone network (60). The substation (50) is connected to an electricity distribution network (10) which feeds a plurality of residential consumers (20, 30, 40) and at least one commercial consumer (100). Each consumer (20, 30, 40, 100) has a RF interface (26, 36, 46, 160) through which their computers (24, 34, 44, 110) connect to the electricity distribution network (10). For commercial customers, only one RF interface (160) may be required to provide Internet access through which other computers (120, 130, 140) may be connected. RF interface (160) is connected to one computer (110) which is connected to an internal computer network (150), the remaining computers (120, 130, 140) being connected to the network (150). The computers use appropriate software for modulation, demodulation and decoding of the RF signals used as carriers. The data may alternatively be transmitted via a cable TV network.



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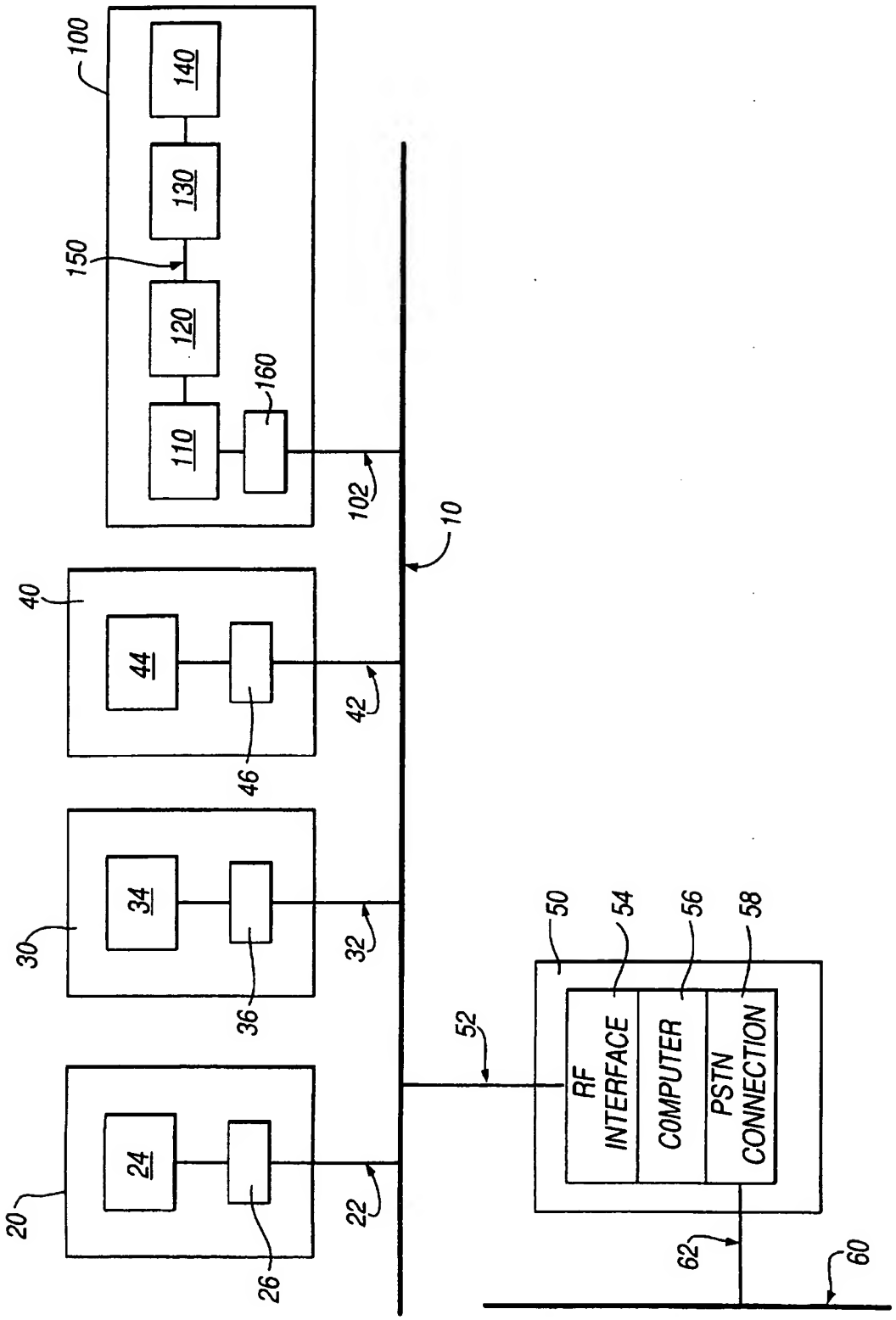
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.


100
140
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RF INTERFACE
COMPUTER
PSTN CONNECTION
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IMPROVEMENTS IN OR RELATING TO DATA TRANSMISSION

The present invention relates to improvements in or relating to data transmission and is more particularly, although not exclusively, concerned with providing Internet access or other data transference between computers using radio frequency communications via power lines.

The Internet and World Wide Web are well-established communication means and vast sources of information. Companies rely heavily on electronic mail for intra- and inter-company communication. Additionally, domestic users of the Internet are rapidly growing and facilities, targeted specially for the home user, are quickly becoming available, such as home-shopping, home-banking etc. All of these use the Internet as their backbone for data and information transfer.

It is known to use a low voltage electricity distribution network to provide local access to basic telephone services. One such system is described in GB-A-2 295 521. GB-A-2 295 521 discloses a line communication system in which a plurality of telephone subscribers are linked to a public telephone exchange via one or more conductors of a mains electricity supply network. Each subscriber's handset is coupled to a CT2 radio unit via a line interface unit. Signals from the radio unit are fed to a conductor via a frequency converter and an interface unit. The interface unit is fed with mains electricity from an electricity substation. The public telephone exchange is linked to the mains electricity supply via a second interface unit and a CT2 radio base station – the base station being fed from the second interface unit via a second frequency converter which converts high frequency (HF) signals transmitted from telephone subscribers via the electricity supply conductors and the second interface unit to ultra high frequency (UHF) signals. The radio channel for a given link is automatically

selected by the CT2 protocol and associated with a public exchange address, a telephone number, which the telephone exchange can understand. Different HF signals can be utilised to serve different groups of telephone subscribers.

However, systems such as that described in GB-A-2 295 521 tend to have low data rates, typically less than 32kbit/s, which do not provide good Internet access or data transfer rates. Furthermore, specialist hardware is required which is both costly and time consuming to develop and manufacture.

It is therefore an object of the present invention to provide a method for Internet or other data access for computers which also has an improved data rate.

In accordance with one aspect of the present invention, there is provided a method of providing data transmission using radio frequency modulations via distribution networks, the method comprising:-

connecting at least one substation to a distribution network;

connecting a plurality of customers to the distribution network, each customer having at least one interface means for interfacing with the distribution network;

connecting said at least one substation to a data network, each substation having first interface means for interfacing with the distribution network and second interface means for interfacing with the data network; and

transmitting data between customers and substations and vice versa;

characterised in that the method further comprises using at least one processor means at each customer and a complementary processor at the substation for modulating radio frequency signals for transmission and for demodulating radio frequency signals received from the distribution network.

In one embodiment of the present invention, the distribution network comprises an electricity distribution network and power line communication is used as a means of enhancing access to the Internet via high-speed, large bandwidth lines to commercial and domestic users by using the existing power line infrastructure. Typical improved data rates in accordance with the present invention are 1Mbit/s.

The method of the present invention utilises radio frequency (RF) modulation and demodulation which is carried out by the computers themselves. This achieves a reduction in cost. Furthermore, the hardware requirements are much simplified which also reduces the cost.

It will readily be appreciated that, in accordance with the method of the present invention, the processes by which modulation and demodulation are carried out can easily be upgraded or configured to suit particular applications by the development and installation of new codes.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawing, the single Figure of which illustrates a block diagram of a network arrangement in accordance with the present invention.

Referring to the Figure, an electricity distribution network (EDN) 10 is shown to which a plurality of domestic customers 20, 30, 40 are connected via connections 22, 32, 42 respectively. An electricity substation 50 is connected to the network 10 via connection 52 and also to a telephone network 60 via connection 62. Each domestic customer 20, 30, 40 comprises a computer 24, 34, 44 which is connected to a radio frequency (RF) interface 26, 36, 46 which interfaces with the network 10 via connections 22, 32, 42 as shown.

A commercial customer 100 is also shown connected to the EDN 10 via connection 102. In the illustrated example, the commercial customer

comprises a plurality of computers 110, 120, 130, 140 connected to an internal network 150. In this case, only one computer 110 is connected to an RF interface 160 for interfacing with the network 10 via connection 102.

The electricity substation 50 comprises an RF interface 54, a computer 56 and a public service telephone network (PSTN) connection 58. The PSTN connection 58 provides the connection with the telephone network 60 via connection 62. The telephone service provider may choose the method by which the telephone network 60 is connected to the substation 50. For example, the connection may be made using synchronous digital hierarchy (SDH), a fibre-optic link, digital subscriber lines (xDSL), a microwave or radio frequency (RF) link, an integrated subscriber digital network (ISDN), or a leased land-line. This list is not intended to be exhaustive, but is an illustration of the different methods by which connection can be made between the telephone network 60 and the substation 50.

The connection between the substation 50 and the telephone network 60 comprises the data-link to the electricity provider's Internet service provider (ISP) and is bi-directional having a downstream path (from telephone network to substation) and an upstream path (from substation to telephone network). It will readily be appreciated that the electricity provider may also be, or decide to become, an ISP.

Similarly, the connections 22, 32, 42, 102 between the RF interfaces 26, 36, 46, 160 and the EDN 10 are bi-directional – each having a downstream path and an upstream path.

It will readily be appreciated that the number of domestic customers can be more than three – each customer having its own RF interface through which it interfaces with the EDN. It will also be appreciated that many commercial customers can be connected to the EDN. It may also be

advantageous for each commercial customer have more than one RF interface for interfacing with the EDN according to their business needs.

In accordance with the present invention, domestic and commercial customers have access to the Internet via the connections to the EDN through conventional means, that is, through their computers. However, the difference between conventional connection and the present invention is that the RF interface attached to the computer is connected to the incoming mains on their premises instead of to a telephone line. Only simple cabling is required and some extra low cost hardware, all of which may reside inside the computer itself, will be needed to complete the communications link with the ISP.

A significant benefit to the user is that the connection to the ISP is available "on demand" and does not require a 'dial-up' connection as for a telephone line.

Data transfer to a customer or subscriber, for example, customer 20, occurs with data arriving at the substation 50 from the chosen ISP via an appropriate link, for example, an asymmetric digital subscriber line (ADSL), connected to the telephone network 60. The substation 50 decodes this data and re-modulates it using a modulation scheme, such as orthogonal frequency division multiplex (OFDM) for example, adding any required extra protocol, for transmission down the power line to the customer or subscriber in the form of an RF signal. Equipment (not shown) located in RF interface 26 down-converts and digitises the RF signal captured from the power line and feeds the digitised version thereof to the computer 24. The computer 24 then carries out the whole of the digital data demodulation and decoding using appropriate software. Although operation has been described with reference to one customer, it will readily be appreciated that each customer will receive information from the Internet in the same way.

Similarly, it can be seen that a complementary modulation/demodulation process is carried out by the computer 56 at the substation 50 to complete the data link to the ISP.

With the rapid increase of computing power, computers now commonly have 400MHz Pentium processors – the computer itself can demodulate and decode the RF signal once it has been digitised. The RF interface shown at the customer's end requires, therefore, very simple RF hardware, with associated low cost, with all the necessary data decoding performed in software. Personal computers can also demodulate and decode live OFDM signals including fast Fourier transform (FFT) and error correction processing. This is a particularly computationally intensive modulation scheme. This has been demonstrated using a live digital audio broadcast (DAB) signal.

There are various criteria which need to be considered when designing the system. These criteria include channel characteristics, modulation technique, the maximum number of subscribers using the system, average data rate, maximum data rate, interface(s) at the subscriber's premises, interface(s) at the provider's site, and communication protocol between subscriber and substation.

The above items are interrelated; for example, the channel characteristics will be a major, if not deciding, factor in the choice of RF modulation technique employed for the digital data transmission.

As transmission is via an EDN, the channel consists of a copper or aluminium core, that is, one phase of the three-phase electricity distribution system. In the United States, the cables are open, overhead medium voltage power lines carrying the three phases and a neutral. In the United Kingdom, the low voltage distribution system is underground and the cables consist of three insulated aluminium cores, shaped to make a circular cross section

carrying the three phases. These are then enclosed in an aluminium tube making up the neutral conductor.

UK cabling is subject to many impairments, which are typical of most installations across the world. These impairments include multiple reflections (that is, multi-path signals) due to spurs, group delay distortion up to several microseconds, impulse noise, and insertion loss of from about 20dB to approximately 90dB.

The above mentioned impairments may be overcome by having a modulation technique which has multipath resistance, spectral efficiency, simple tracking and synchronisation, and good linearity.

Suitable RF modulation techniques include quadrature amplitude modulation (QAM), OFDM, direct sequence spread spectrum (DSSS), M-ary frequency shifted keying (FSK) and asynchronous multi-tone frequency division multiple access (AMT-FDMA). Each technique has its own advantages and disadvantages. At present, OFDM represents the best choice for both the upstream and downstream links, but it will readily be appreciated that other modulation techniques may be more appropriate according to the particular system. Although, OFDM is used for both the downstream and upstream links, it will be appreciated that it is not necessary to use the same modulation technique for both links. The requirements for each link are different and, therefore, different modulation techniques may be more suitable for the downstream link than the upstream link and vice versa. Downstream communication may be similar to broadcasting, that is, one substation to many customers, whereas in upstream communication, the link is many to one.

Possible interfaces that may be used at the customer's site include Ethernet, universal serial bus (USB), IEEE-1394 (termed "FireWire"), in-

house power line and RS-485 differential serial. Other interfaces may also be suitable, such as, connection to a computer's parallel port.

Key features of such a system incorporating the present invention include high-speed Internet access (up to at least 1Mbit/s) on demand via the electricity distribution network to either a PC or a digital TV; data demodulation and decoding in software at the customer's site, giving an inexpensive implementation with simple hardware; the use of either the same or different, suitable modulation techniques for the upstream and downstream links; a transparent link as seen by the user by using a communications protocol between the user's site and the substation; multiple subscriber access, with total capacity shared between the active subscribers; mains isolated RF connection to the network at each access point; downloadable software upgrades for the data demodulation and decoding; higher bandwidth communication support by using extra equipment at the substations; statistical monitoring of network usage; and statistical allocation of network bandwidth.

It will readily be appreciated that although the present invention has been described above with reference to an electricity distribution network, it is equally applicable to other networks which are able to carry radio frequency signals, such as, cable TV networks.

At the customer end of a network, the PCs may be replaced by a dedicated embedded processor which is incorporated into the appropriate decoding device or built into a digital TV set.

As previously described, the hardware requirements for implementation of the present invention are much simplified – only RF interfaces, analogue-to-digital converters, digital-to-analogue converters, and PC bus interfaces are necessary. Moreover, as modulation and demodulation

are implemented in software, there is no need to develop application specific integrated circuits (ASICs) for this implementation.

CLAIMS:

1. A method of data transmission using radio frequency modulations via distribution networks, the method comprising:-

connecting at least one substation to a distribution network;

connecting a plurality of customers to the distribution network, each customer having at least one interface means for interfacing with the distribution network;

connecting said at least one substation to a data network, each substation having first interface means for interfacing with the distribution network and second interface means for interfacing with the data network; and

transmitting data between customers and substations and vice versa;

characterised in that the method further comprises using at least one processor means at each customer and a complementary processor at the substation for modulating radio frequency signals for transmission and for demodulating radio frequency signals received from the distribution network.

2. A method according to claim 1, wherein the distribution network comprises an electricity distribution network and the substation comprises an electricity substation.

3. A method according to claim 1, wherein the distribution network comprises a cable TV network.

4. A method according to any one of claims 1 to 3, wherein said at least one processor means comprises an embedded processor.

5. A method according to any one of claims 1 to 3, wherein said at least one processor means comprises a computer.

6. A method according to claim 5, wherein the computer comprises a personal computer (PC).

7. A method substantially as hereinbefore described with reference to the accompanying drawing.

Application No: GB 9908261.2 **Examiner:** Mr.Sat Satkurunath
Claims searched: ALL **Date of search:** 22 June 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4R: RTC, RTSR, RTSU, RCC, RCT, RCSC, RCX

Int Cl (Ed.6): H04B, H04H, H04M, H04N

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2322518 A	MOTOROLA - see especially figures 1-4 and lines 14-18 on page 8	1, 3
X	EP 0899925 A	ATCOM - see especially pages 1, 4 and figures 2-5	1, 3
X	EP0859515 A	SONY - see especially page 1 and figure 1	1, 3
X	WO98/18247 A	GARCIA - see especially page 1 and figures 14-16	1, 3
A	US 5828293	NORTHERN - see especially lines 24-26 on page 3 and figure 1	1, 2
A	US 4357605	CLEMENTS - see especially figure 2	1, 2

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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E Patent document published on or after, but with priority date earlier than, the filing date of this application.